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DRAFT IN LIEU
OF FINAL
D9-CR

JULY 1972

Preliminary Analysis of R&D Planning

by Fred M. Newman
William H. Sutherland
Roland V. Tiede

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RAC Research Analysis Corporation

SCIENCE AND TECHNOLOGY DEPARTMENT   DRAFT IN LIEU OF FINAL D9-CR   Published July 1972

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FOREWORD

This report has been prepared in an endeavor to salvage as much useful information as possible from the effort expended between 1 September and 31 December 1971 on RAC Project 012.123, "Advanced Technology and R&D Planning." This study, sponsored by the Office of the Chief of Research and Development (OCRD), US Army, was initiated 1 September 1971 and terminated, as a result of congressional budget action, on 31 December 1971.

This report addresses the initial research objective which was to establish a basis for determining feasible improvements to the existing planning/decision making system. It examines the purpose and nature of Army R&D planning as a part of the overall Army development process. It describes in broad terms the existing planning/decision making system for R&D including both its formal and informal structure. It then goes on to highlight some of the major deficiencies in that system and to recommend a number of feasible improvements. Probably the most significant contribution of this report lies in the concise basis it establishes for relating, i.e. cross-walking, among budget entities, R&D objectives, and technologies. These and other essential elements of information are contained in the documents being produced at the various hierarchical levels in the Army R&D community, but these elements are not now relatable in a concise and structured manner. This report also establishes a basis for priority determination and for answering certain planning and "what if" questions such as "how should the tech base be sized and balanced"? "what are the impacts of a budget reduction in the RDTE ceiling?" etc.

J. ROSS HEVERLY
Vice President
Technological Systems

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SUMMARY

PROBLEM

To describe the present R&D planning/decision making system as it exists today; to identify the requirement for information/direction at each major echelon in the system; and to determine how the system can be improved and yet remain feasible in the real world.

BACKGROUND

This study initiated by RAC on 1 September 1971 had the primary objective of providing a basis for OCRD actions to: (a) improve R&D planning, (b) provide for a properly sized and balanced technology base effort, and (c) improve management of system development efforts. To achieve these objectives, the initial research objectives outlined under PROBLEM, above, were agreed to by the sponsor. Termination of the study effective 31 December cut short the planned effort on these initial objectives, but this report provides that information which was developed.

DISCUSSION

In an endeavor to set the stage for the review of the existing system and a critical analysis to determine feasible improvements, the study begins with a review of the purpose and nature of long range planning. Army R&D is then identified as a part of the larger, continuing activity known as Development of the Army. The sequential nature of the steps in that activity is described as well as the pertinent goals and constraints on each. The dynamic nature of the development process is described and the implications arising from the fact that the Planning, Programming, Budgeting (PPB) horizon of

five years is overlayed on a process that may simultaneously extend up to 25 years into the future and into the past. The urgency of establishing a hierarchy of planning goals achievable within the PPB horizon is stressed as is the necessity of being able to measure progress toward these goals if R&D plans are to be used for control.

The existing planning/decision making system is examined both with respect to its formal and informal structure. Its inherent complexity results, in part, from its cyclical nature as a part of the budget cycle and from the proliferation of general planning documents at DOD and DA level. The existing R&D planning documents are depicted by echelon and sorted as to content and fiscal information. A clear pattern emerges for the flow of information, but the pattern is far less clear for content. It is also noted that the interconnections between content guidance and fiscal guidance seem less than adequate. It is observed that at least some of the formal paperwork serves only formalistic purposes and that most of the actual content is provided almost exclusively by the informal information network.

The planning/decision making system is then examined from the point of view of an integrated R&D planning system. Such a system is postulated and some of its necessary characteristics are defined. Shortcomings in the existing formal system are isolated. The structure of a conceptual information system which does have the required characteristics to facilitate the desired decision making is then defined. Relationships are established among Budget Entities (BEs), Materiel Needs (MNs), Research/Technology Objectives (RTOs), Threats (Ts) and other Essential Elements of Information (EEI) necessary for establishing priorities, for cross referencing and for providing planners concise and structured information. Rules for sizing budget entities so as to permit costing of collections of MNs and RTOs despite costing interdependencies are derived.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions are drawn from the above discussion and analysis:

1. The formal system for dissemination of RDTE planning information and substantive and coherent guidance pertinent for control of Army RDTE effort is replete with documentation that is redundant, inconsistent, incompatible and often incomplete or irrelevant for planning/decision purposes.

2. An informal system exists, consisting of directives, memos, phone calls, conferences and meetings, through which the planning and substantive guidance is effected.

3. At OCRD level, financial plans are used as the principal means of control of the RDTE program. Little attention is given to guiding the technology and system mix content of the total RDTE effort. OCRD must ask itself whether it should, or desires to, influence the program content of the RDTE effort--and whether it could obtain the required information and expertise for this task.

4. The current efforts to develop a formally integrated RDTE planning system from laboratory and commodity command level up through OCRD and ODDRE level is an important first step toward corresting deficiencies in the existing system. However, unless a set of specific planning and decision issues are defined which are meant to be addressed by users of the system, current problems will subsist concerning the individual and collective use of the documents comprising the system. Additionally, subsequent iterations of these documents must be developed within a framework that consists of integrated formats and compatible structures in order that cross referencing capability is provided. This cannot be accomplished, however, unless the responsibility for vertical integration of the system elements is defined and delegated.

5. A major weakness of the current planning system is a lack of consistent and operationally defined priorities. Many versions of priorities currently exist including ASOP priorities, CDOG priorities, and ACSFOR priorities. There is no mechanism guaranteeing the consistency of these different priorities. More important, however, is the fact that these priorities cannot be unambiguously translated into resource implications. The rationale or fundamental bases underlying the established priority values is also clouded. That is, implicit in the development of individual priorities are considerations of threat assessment, performance parameter improvement possibilities, life cycle system savings, improved maintainability, and reliability or human factors considerations. However, these considerations are rarely explicitly surfaced as priority determinants.

6. A single priority system should be established for the total RDTE program. It should be defined in operational terms such as the

specification of milestones for a specific MN which cannot be allowed to slip more than X years, or funds for a specific budget entity which cannot be reduced by more than Y%.

7. The computer based man-machine interactive RDTE integrated planning system discussed in the body of this report should be considered for development in order to provide OCRD a planning tool for evaluating alternative RDTE plans and as a mechanism for developing and testing program content guidance that might be promulgated to the field. The system will also provide the framework for effecting the integration of the various planning documents illustrated in Fig. 4-1 by requiring common structures and formats, and consistent, compatible and complete data. Additionally, the system will provide a convenient storage, retrieval, and processing device for manipulating and synthesizing large amounts of planning data for use in quick reaction and "what if" planning exercises.

PRELIMINARY ANALYSIS OF R&D PLANNING

Chapter 1

INTRODUCTION

Since February 1970, the Research Analysis Corporation (RAC) has undertaken a series of studies for the Army Office of the Chief of Research and Development (OCRD). The basic theme underlying these studies has been an effort to improve the management of Army R&D. They have addressed such key management issues as: resource allocation strategies, assistance in developing a series of planning documents, technological forecasting, threat forecasting, and development of an on-line programming and budgeting system (MEASURE II).

The current study, entitled "Advanced Technology and Army R&D Planning," was initiated on 1 September 1971. Its objective was to provide a basis for OCRD actions to: (a) improve R&D planning, (b) provide for a properly sized and balanced technology base effort, and (c) improve management of system development efforts. In order to accomplish these study objectives, RAC proposed and the Study Advisory Group approved the following initial research objectives at its 28 October 1971 meeting:

1. Describe the present planning/decision making system as it exists today.
2. Identify the requirement for information/direction at each major echelon in the system.
3. Determine how the system can be improved and yet remain feasible in the real world.

These initial research objectives would be reached by means of a literature search of the existing instructions, directions, regulations and other formal documents to be supplemented by a series of interviews at major echelons. Analysis of the data gathered in this way would provide the basis for the recommended improvements. It was agreed that this initial phase would be completed and an interim report submitted by 15 January 1972.

Approximately 1 December RAC was informed that this study was among those to be terminated effective 1 January as a result of a congressionally imposed ceiling on the RAC study effort. Under these circumstances the study team decided that the best course of action would be to stop the data collection effort on the existing R&D system and to concentrate the effort for the short time remaining on pulling togeth · and analyzing data already collected. It was hoped that, in this way, the maximum amount of useful information could be salvaged in the form of a preliminary report. The conclusions reached in the following chapters must, therefore, be regarded as tentative, but they are nonetheless presented in the hope that they may be of some value.

Chapter 2

PURPOSE AND NATURE OF MILITARY R&D PLANNING

PURPOSE

Since the adoption of the planning, programming, budgeting system (PPBS) by the Department of Defense in 1961, there has been a tendency to restrict the scope of planning activities through arbitrary institutional constraints despite the basic interdependencies of these activities. Many defense agencies have found it convenient to organize their PPBS functions into an independent planning responsibility and a separate programming/budgeting responsibility. As a result the word "planning" frequently evokes the notion of a rather more limited set of activities within the Army than was visualized by the initiators of PPBS and a definitely more restricted scope than is associated either with military operational planning or with business planning.

The sense in which we intend to use the word planning, as applied to the management of military R&D, has been best expressed by Koontz and McDonnell in their standard text on Principles of Management[1/]:

> Long-range planning is risk-taking decision making. As such it is the responsibility of the policy-maker, whether we call him entrepreneur or manager. To do the job rationally and systematically does not change this. Long-range planning does not 'substitute facts for judgment,' does not 'substitute science for the manager.' It does not even lessen the importance and role of managerial ability, courage, experience, intuition, or hunch. .... On the contrary, the systematic organization of the planning job and supply of knowledge to it should make more effective managerial qualities of personality and vision.
>
> Planning is one of the functions of the manager and, as such, involves the selection from among alternatives, of enterprise objectives, policies, procedures,

> and programs. It is thus decision making affecting the future course of an enterprise.
>
> It is sometimes said that planning is the primary managerial function which logically precedes all other functions, since, without planning, a manager would not have activities to organize, would not require a staff, and would have no need to control. However the managerial job is actually one in which all the managerial functions take place simultaneously rather than serially.
>
> While no manager can successfully accomplish his task unless he does all his functions well, it is nonetheless true, control is peculiarly dependent on planning. Since control is the function of making sure that events conform to plans, no manager can control who has not planned. No one can ascertain whether he is on the correct path unless he has determined where he wishes to go ....
>
> .... Planning is to a large extent the job of making things happen that would not otherwise occur.

One other quotation is pertinent, this time from the opening sentence of the chapter on Plans and Planning, FM 101-5[2/]:

> Planning and preparation of plans are integral parts of the sequence of actions in making and executing a decision.

Planning is, therefore, an essential ingredient of decision making under conditions of uncertainty. The context in which it will be used in this report is that the purpose of planning is to assist the decision maker in making today's decision by:

a. Defining a series of goals which can be thought of as desirable future states of the world.

b. Defining logical sequences of actions which will increase the probability of transforming the present state of the world into the desired future states.

c. Providing means to:

. Determine sets of objectives that are feasible of achievement within the anticipated constraints, fiscal and other.

.. Evaluate alternative feasible sets according to policy or strategy.

d. Providing a blueprint against which to measure progress--thus to provide an essential ingredient of control.

DEVELOPMENT OF THE ARMY

Having defined the purpose of planning, one needs to examine briefly the enterprise for which the planning is being done to gain insight into the nature of the R&D planning process. Central to this enterprise, which we can designate as the continuing development of the Army, is a series of developmental activities. Figure 2-1 provides a broad overview of these activities. Across the center band of the figure are listed pertinent activities and their outputs beginning with research at the extreme left and ending with operation of the forces at the extreme right. These activities have been divided into "soft" and "hard", i.e., preponderantly social vs. physical, by a dotted line; this distinction probably becomes increasingly blurred and indistinct as one moves from research across the spectrum of activities to force operation at the right. Above each activity are listed the most important goals to be achieved by that activity. These goals range in time from the present for force operation, at the right of the figure, into the future as we move leftward across the figure. The goals for the research activities at the extreme left are so broad as to transcend time in some sense. Across the bottom of the figure are listed the principal constraints that limit the achievement of goals for each of the listed activities. The shaded portion of the activities, which becomes progressively smaller as one moves from research at the left to force operation at the right, is a qualitative representation of the involvement of "R&D" in the successive steps of Army development. The involvement of what is commonly thought of as "R&D" in force operation, for example, is pretty much limited to product improvement.

Such an overview of Army development does provide the neophyte with some insights into the nature of the enterprise (the experienced R&D manager will more likely term them truisms, but can gain some solace from the fact that they appear to agree with his experience). We are reminded that this development is a truly dynamic enterprise. While the activities occur in a time progression as related to the force as it will exist at any specified future time, they are also all occuring simultaneously. At any particular instant, each activity is contributing to the force as it will exist at different future time. Typically,

Fig. 2-1—**CONTINUING DEVELOPMENT OF THE ARMY**

	SATISFY CURIOSITY AND OTHER "PEOPLE" URGES		SATISFY LONG RANGE (LR) ARMY GOALS (10-20 Years)		SATISFY MID RANGE (MR) ARMY GOALS (2-10 Years)		SATISFY SHORT RANGE (SR) ARMY GOALS (0-2 Years)		CARRY OUT ARMY OPERATIONAL MISSIONS
GOALS	Activity	Output	Activity	Output	Activity	Output	Activity	Output	
SOFT	PEOPLE RESEARCH	Forecast Behavior Known Behavior	Estimate LR Threat & GENERATE CONCEPTS	Org'n & Doctr'l Concepts	Estimate MR Threat REFINE CONCEPTS	Future Org'n & Doctr'	Estimate SR Threat FORCE DEVELOPMENT	Force Structure	OPERATE (Build, Train, Deploy, Maintain)
HARD	PHYSICAL RESEARCH	Technological Forecast Technological Capabilities		MATERIEL NEEDS	DETERMINE FEASIBILITY	PROTOTYPES	PROCUREMENT	HARDWARE	FORCES
CONSTRAINTS	Skilled People (Imagination)		Technological Base & Skilled People (Imagination)		Fiscal Available Concepts Bureaucratic Inertia		Fiscal Accepted Doctrine, Organization and Available Prototypes Inventory		National Will and Capacity Existing Force, Doctrine, and Structure

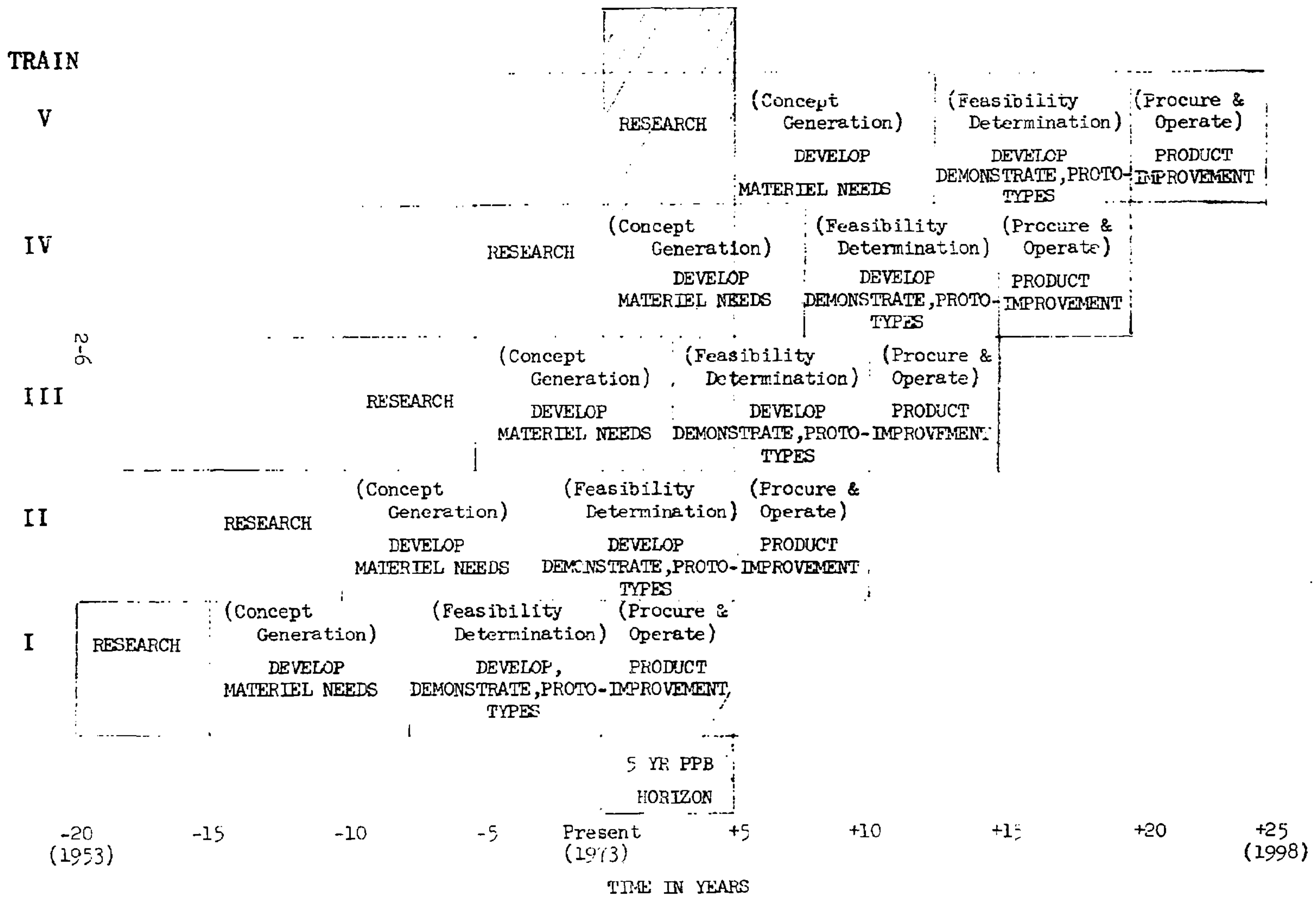
Qualitative Involvement of R&D

for the research activity at the left, the time frame of the operational capability to which that research may contribute cannot be estimated with any degree of certainty.

What such a view of the world of Army development seems to imply is that the activities labeled "Research" are basically explorative, i.e., their contribution to the ultimate goal or carrying out future operational missions is essentially a random process. However, once we move into concept generation, bearing in mind that Army goals become more and more explicit as we move from Long-Range Goals down to current operational goals, we see that the activities become increasingly normative. In other words, development consists of a series of decisions which become increasingly selective as we move from the smorgasbord of the technological base at the left to the operational force at the right. The corollary to that observation is, of course, that the set of choices made at each stage becomes one of the constraints on the next. This is reflected in the fact that the output of each activity is shown as one of the constraints for the following activity.

Thus, Fig. 2-1 can be thought of as a moving train which moves from research at the left to an operational force at the right. But, inasmuch as all activities are being pursued simultaneously, it is really a whole series of moving trains each of which becomes operational at a different time. This concept is expanded in Fig. 2-2. In order to simplify the portrayal, all developments completed in a five year period have been lumped into a single "train." In addition, arbitrary time durations have been assigned to each of the major activities identified in Fig. 2-1 except for research which is assumed to be a continuing activity of which only the final 5 years are considered. Concept Generation and Feasibility have been assigned a duration of $7\frac{1}{2}$ years each and Procurement and Operation have jointly been assigned a duration of 5 years principally on the basis that the involvement of R&D in the train beyond that point is not too significant. Referring to Train I at the bottom of Fig. 2-2, the boxes representing the major development activities have been scaled to represent the above time periods. For activities other than Research, the lower case entry in parenthesis is

Fig. 2-2—THE MOVING TRAINS OF ARMY DEVELOPMENT



the name of the total development activity, e.g., Concept Generation. Shown in capital letters below it is the major R&D activity included, e.g., DEVELOP MATERIEL NEEDS. Train I has been placed on the time scale at the bottom of the figure so that the final activity, Procure & Operate, begins at the present time (beginning FY1973). The final 5 years of research for that train began 20 years ago in 1953. Each of the succeeding trains, II, III, IV, and V, has been plotted so as lag its predecessor by 5 years so that Train V has a research box for which a 5 year period begins at the present time and for which R&D is reasonably complete in 25 years or 1998. Thus the 5 trains now in the system span a total of nearly half a century.

If we superimpose the 5-year planning horizon of the PPB process we get the shaded section at the center of Fig. 2-2. This illustrates that PPB funding and content decisions affect a different set of activities for each of the moving trains and that such decisions must consider an extremely diverse set of goals and constraints.

Considering each of the trains individually, Train I items appearing in the 5-year R&D funding schedule beginning with FY1973 are concerned solely with satisfying short-range and operational Army goals. They will be limited to product improvement that will affect well-defined systems or systems already in being. Alternative funding profiles for Train I items can be easily and unambiguously related to specific milestone slippages and/or specific changes in performance parameters.

Train II items in the FY1973-78 funding schedule will be in the final five years of feasibility determination, i.e., prototype development and demonstration. These should, during FY1973 budget preparation, be relatable to satisfying Army mid-range goals. Since materiel needs have been reasonably well specified at this stage of development, alternative funding profiles are again directly relatable to development milestones and system performance parameters. It must be recognized, however, that the goals for Train II items are somewhat longer range than were those for Train I, hence schedules for their satisfaction involve projections somewhat farther into the future and are necessarily less certain.

Train III items in the FY1973-78 funding schedule concern items that are in the final stages of concept generation and in the initial stages of feasibility determination. Clearly, the goals they are designed to meet are still more distant. Rarely will it be possible to express the impact of alternative funding profiles for such items in terms of system milestones and final system performance parameters. Instead, they must be related to intermediate goals which have two prime qualities. First, they must be goals such that progress to their accomplishment is measurable within the PPB horizon if the funding plan is to be useful for control. Second, intermediate goals must be such that they simultaneously lead to the final goals yet do not unduly restrict the development process by imposing constraints too early. Such intermediate goals are usually described as technological objectives.

Train IV items in the FY1973-78 funding schedule consist of items in the early stages of concept generation. It is quite clear that such items can hardly be related in any meaningful way to milestones and performance parameters that have not yet been established. Intermediate or technological objectives are certainly the only appropriate goals for these items. At about this stage it must also be noted that such intermediate or technological goals can be and frequently are relatable to more than one longer range operational goal. In fact, if achieved, such a technological goal can frequently make a potential contribution to an operational goal carried in an earlier Train. It is precisely this logical possibility that can and sometimes does lead to unnecessary complexity and cross-coupling between R&D objectives. Carried to excess, such unwarranted cross-coupling simply leads to confusion between technological objectives with a reasonable probability of achievement within the PPB planning horizon and far less probable potential application to specific end items also in the PPB planning horizon. Nevertheless such unwarranted cross-coupling frequently occurs in order to provide pseudo-justification for exploratory development.

Train V items in the 73-78 funding schedule deal exclusively with research activities. We have already noted that this activity is essentially exploratory rather than normative, i.e., its output, the technological base, is a major constraint on the next major activity, Concept Generation, but its goals are highly personal and cannot be definitively related with the technological base. We have also noted that this is a continuing activity whose apparent technological goals are not quantifiable nor reducible to time schedules. In fact, it exhibits many of the characteristics of a random process. Achievable goals within the PPB horizon must, therefore be related to basically human values that contribute to the retention of skilled personnel. Such considerations are, of course, not absolute. Some normative considerations are applicable. It is, for example, not necessary for the Army to sponsor research in every scientific field. Many fields are adequately covered by other agencies within and outside the government. On the other hand, it is possible to highlight certain areas of research that are important to the Army, not so much to provide the technological breakthrough which is unpredictable, but to insure the ready availability of the skilled people to facilitate the transformation of the breakthrough, wherever it occurs, into practice useful for Army operational objectives.

NATURE

Having developed an overview of the development of the Army in the preceding section and considered the portion of that process that is usually considered to be the proper province of "R&D," we can make the purpose of planning R&D somewhat more explicit.

We stated earlier that the first purpose of planning is to define a series of goals. We have already noted that the Army does define a series of operational goals ranging from the immediate future out to long-range goals that are projected as far as 20 years. These are quite explicit for the near future but become increasingly general and vague the farther they are projected.

The second purpose of planning is to define a logical sequence of actions to increase the probability of achieving operational goals. For R&D, such logical sequences run the gamut from precise and detailed engineering plans for product improvement to even more voluminous system development plans for the development and demonstration of prototypes that establish feasibility. Extending deeper into the operational future, it is necessary to establish intermediate technological objectives which are quantifiable and schedulable and which, in turn, serve simultaneously as springboards for and constraints on the achievement of future operational goals. Finally, looking even deeper into the future, we have noted that it is necessary to maintain a technological base, but that the intermediate objectives for this activity are not readily quantifiable in technological or temporal terms. Instead, it must be somehow related to the urges and desires that motivate skilled people to engage in that activity. This leads to the conclusion that effective R&D planning requires that a hierarchy of planning objectives be developed extending from desired operational cability through technological objective down to research objectives.

The third purpose of planning is to determine sets of objectives feasible of attainment within anticipated constraints so that alternative feasible sets can be evaluated in accordance with some higher set of values, usually termed policy or strategy. We have also noted that the PPB system in use within DOD projects fiscal constraints over a period limited to five years, i.e., the budget year and four. Meaningful constrained planning is therefore essentially limited to this five year period. This raises the matter of establishing a hierarchy of planning objectives to paramount importance. If meaningful constrained planning is going to be done, it must be possible to relate every item in that schedule to an objective achievable within that time frame.

The final and ultimate purpose of R&D planning is to provide a blueprint against which to measure progress, hence to assist in control. This imposes the requirement that not only must budget items be relatable to goals achievable within the PPB horizon, but that they be relatable in a measurable way.

One other comment is appropriate to Army R&D planning. Future operational capabilities are not completely determined by our own hardware, organization and doctrine, but are also a function of enemy capability. For this reason alone, intermediate objectives must be chosen with infinite care. Consideration of flexibility in choosing future developmental approaches may be even more important than choosing the most rapid path toward materializing an operational concept that is based on the wrong threat.

Chapter 3

THE EXISTING PLANNING SYSTEM: A PRELIMINARY VIEW

THE ANATOMY OF THE EXISTING SYSTEM

For purposes of description the planning system can be divided into parts. Like a living organism, the parts cannot work separately, but the division into the functional components is an aid to understanding.

The bones of the planning system are the formal reports and documents that record decisions and indicate priorities, guidance, and official permission to go ahead. They give it structure. The muscles are the substantive R&D plans, while the arteries, veins and capillaries that nourish the system are the fiscal plans. The nerve system that controls the planning process is the network of informal communications that make the system work in spite of twin difficulties: that each research or development program involves substantial uncertainties; and each is substantially different from other programs.

The separation of the description into formal and informal planning on the one hand, and into fiscal and substantive planning on the other hand, is useful. There seems to be no counterpart in the analogy for a third kind of separation used in the descriptive material that follows: i.e., into overall or "between-project" planning on the one hand, and "within-project" planning on the other; the overall planning is emphasized in this chapter.

OVERALL PLANNING - THE FORMAL PLANNING/BUDGETING SYSTEM

Budgeting

The formulation of the part of R&D plans that concerns the between programs plans can be described in an orderly fashion by starting with documents that are promulgated by higher echelons of the military hierarchy and moving toward the documents that are the responsibilities of lower levels. The actual process, for a given fiscal year, is tied strongly to the budget cycle. The information for budget preparation, as outlined in Fig. 3-1, flows upward as well as downward, and the process for completion of a single budget consumes over two years of calendar time. The process starts with the establishment of guidance—fiscal and substantive—at high levels, and the promulgation of this guidance to the lower levels. Then candidate funding plans are made, beginning at the lowest levels, and passed upward, with each echelon on the upward path reconciling differences and balancing programs as its contribution to the planning process. Much of the substantive part of such planning is made concrete by the attachment of fiscal numbers. After approval at the presidential level and congressional appropriations, an allocation process begins and proceeds down through the levels. The description of the documentation—the formal part of the system—is here simplified into an echelon-by-echelon outline. The whole process of preparation is marked by formal and informal exchanges of view at various levels before being put into final (read formal) form.

Planning. Generally speaking, the formal planning system is prescribed in planning documents, regulations, directives, and instructions. Figure 3-2, taken from a draft of a new version of AR 1-1, the Army Planning System illustrates the interrelations among the planning documents. Most but not all of the documents shown bear on R&D in one way or another. In the descriptive material that follows in the present chapter, the phasing is not emphasized so as not to obscure the clarity of the presentation.

Priorities. Parts of the formal system contain statements of priorities. The descriptions of what constitutes Priority I, Priority II, etc., projects are clear. For example, a Priority I is defined in AR 71-1 as "Items of materiel or OCO (Operational Capability Objective) essential to the security of the nation or mandatory for successful

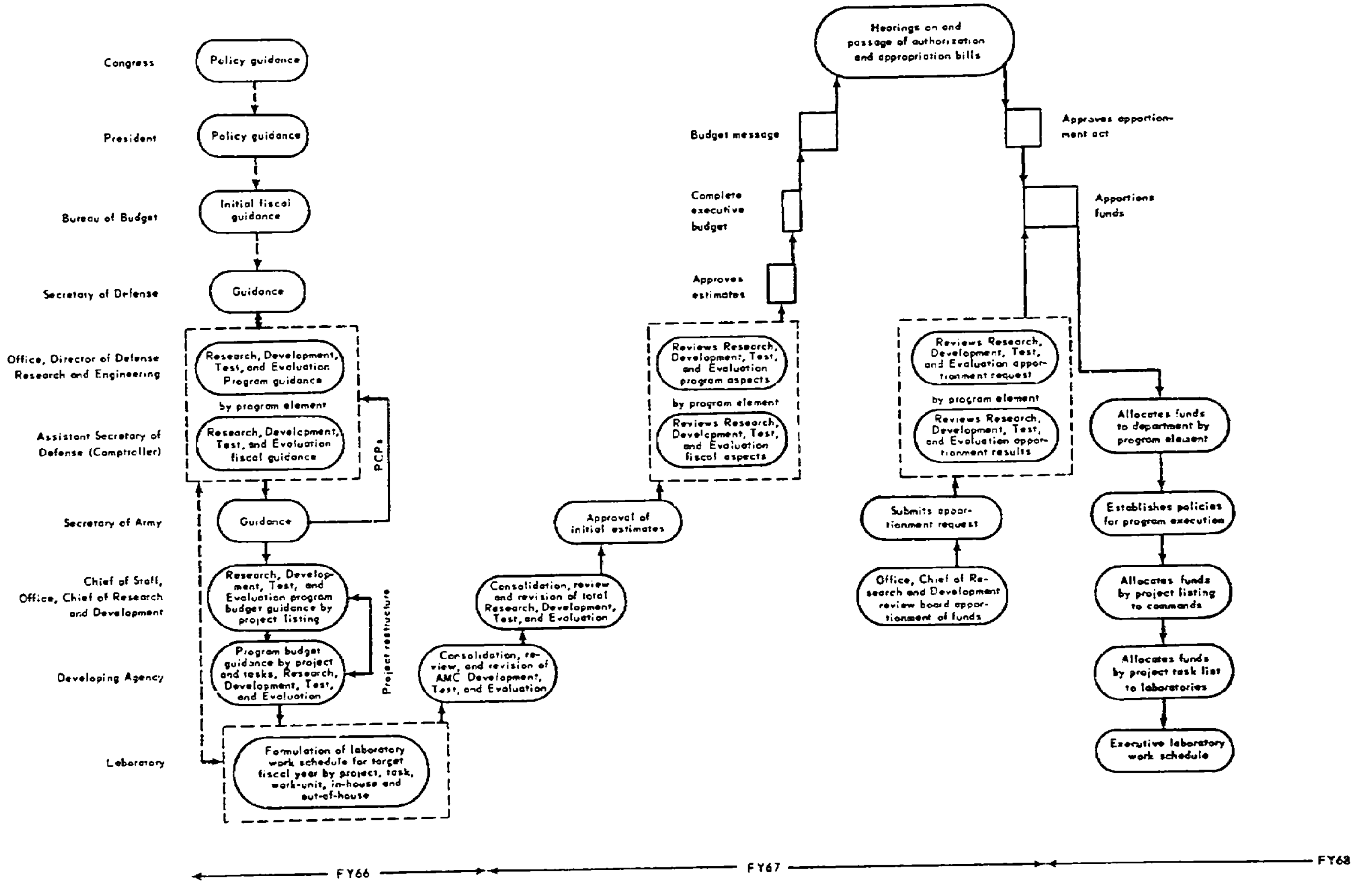


Fig. 3-1—Research and Development Program Budget Cycle for Fiscal Year*

*From RAC TP-236.

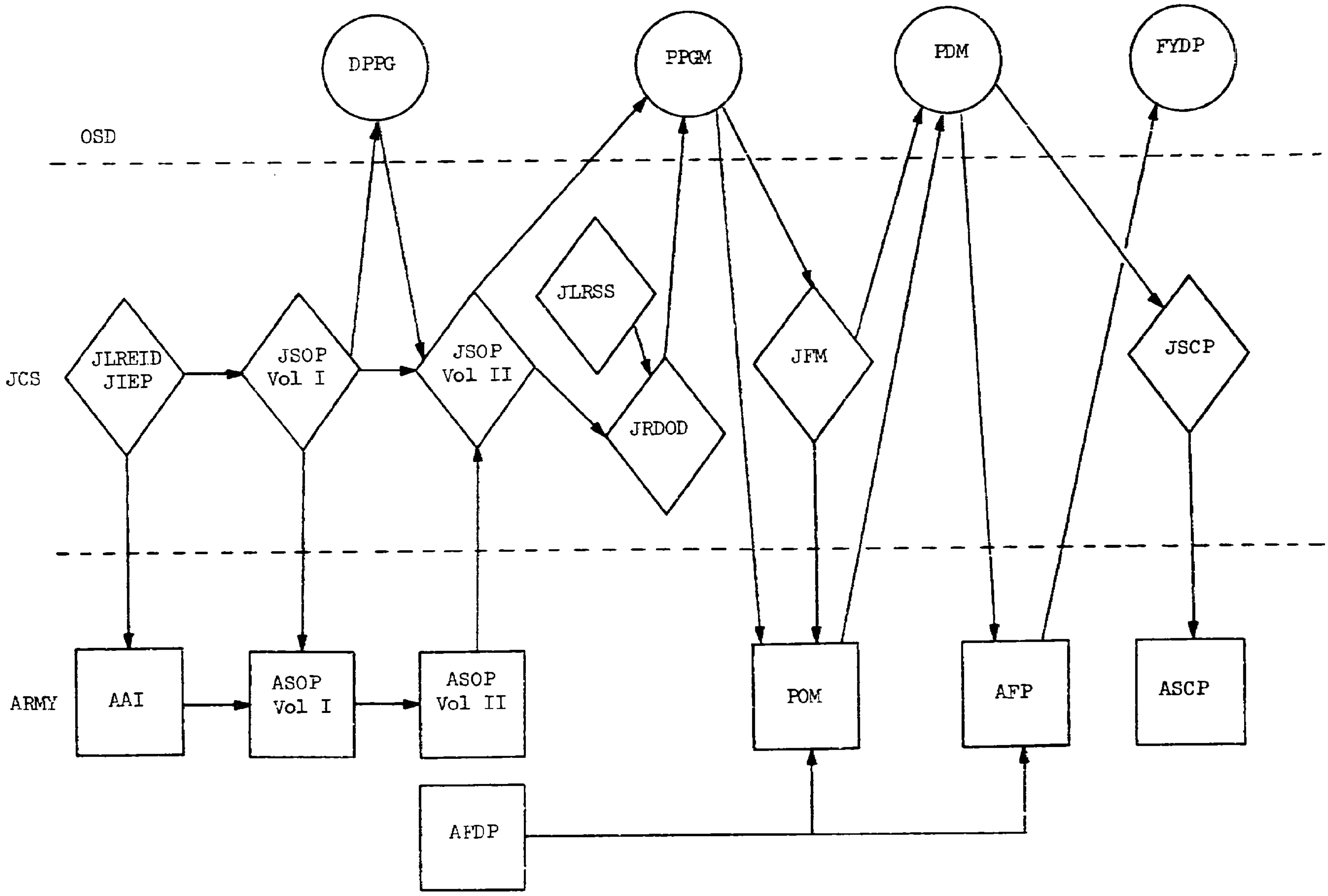


Fig. 3-2—Relationships of Army Plans

accomplishment of assigned mission." What does not come through clearly in the research done so far is the action to be taken as a result of having been categorized as Priority I. One AR in effect says that funds for a Priority I project will be allocated to the project at a sustaining level before any funds at all are allocated to projects with a lesser priority. But the AR does not then go on to specify the manner of allocating to projects categorized as Priority II or less. Because of this lack of spelling out what is to be done with the established priorities, we have reached the tentative conclusion that the formal priority system is one that can be (and is) used only for the roughest sort of guidance.

Description of Formal Planning System

Mechanics of Chart Showing Interrelationships. Fig. 3-3 shows the planning documents that apply directly to the R&D programs, as contrasted to Fig. 3-2, which is applicable to overall Army planning. Figure 3-3 is intended to show the principal documents at various levels, as determined from interviews with a limited number of personnel directly concerned with Army R&D planning. In the diagram the initial letters of the document title are shown. Table 3-1 shows the full names of all document initials referred to. In the diagram where the letters are enclosed in a rectangle or circle the document is one judged to be especially important to R&D planning. Those not enclosed are less important but do have a direct bearing. The arrows indicate some of the input and output relationships. Not all such relationships can be shown—the diagram reflects a view as to which are the important ones. The arrows tend to be related in some degree to the phasing indicated in Fig. 3-1, but to show the phasing with any completeness was impractical in this type of diagram.

Comments on Chart. Looking at the flows of information suggested by Fig. 3-3 as an overall pattern, it will be seen that:

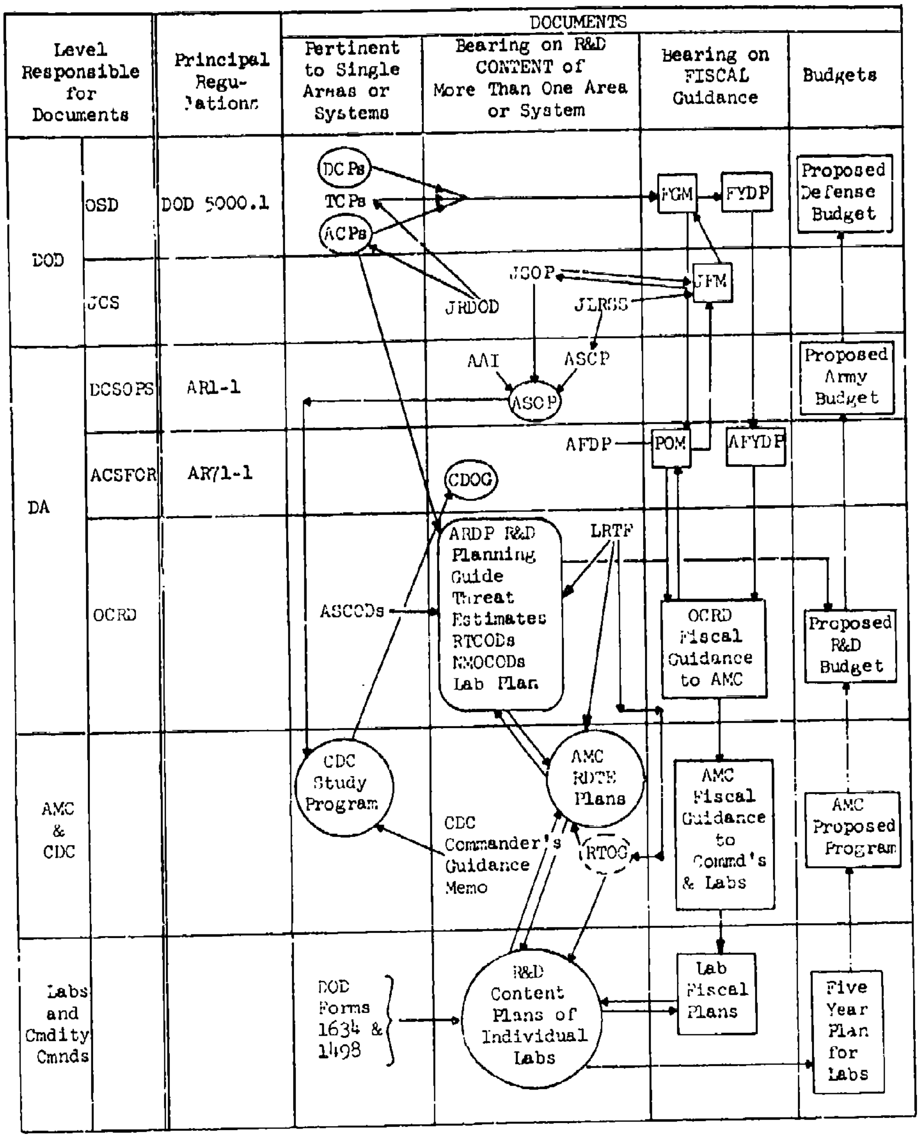
(a) the substantive, or content, information flows both upward and downward within the "CONTENT" column;

(b) there is some interaction between CONTENT and fiscal matters, but not at all levels; and

Table 3-1

KEY SHOWING NAMES OF DOCUMENTS OF FIG. 3-2

AAI	—Army Analysis of Intelligence
AFDP	—Army Force Development Plan
AFP	—Army Force Program (Vol II, AFDP)
ASCP	—Army Strategic Capabilities Plan
ASOP	—Army Strategic Objectives Plan
DPPG	—Defense Policy and Guidance Memorandum
FDP	—Force Development Plan (Vol I, AFDP)
FYDP	—Five Year Defense Program
JFM	—Joint Force Memorandum
JIEP	—Joint Intelligence Estimate for Planning
JLRSS	—Joint Long-Range Strategic Study
JRDOD	—Joint Research and Development Objectives Document
JSCP	—Joint Strategic Capabilities Plan
JSOP	—Joint Strategic Objectives Plan
PPGM	—Planning and Program Guidance Memorandum
PDM	—Program Decision Memorandum
POM	—Program Objective Memorandum



NOTE: Each of the documents indicated has a bearing on R&D plans. Those in boxes and circles are most directly concerned with R&D guidance and control.

Fig. 3-3—Principle Documents Used for "Interproject" Guidance and Control of R&D Programs

(c) there is a flow of fiscal guidance downward and of proposed budgets upward both of which seem reasonably clear cut as compared to the content flow. In fact, the upward flow in the budget column actually combines fiscal and content material into a specific whole, although in this whole the actual content is not always so visible as might be desired.

Note that the problems of aggregating information on fiscal matters is relatively simple. The dollars are made to add up at the various echelons. This probably contributes to the clear cut nature of the flow in the last two columns. For the content column aggregating the substance of research programs is not at all straightforward. For example, the aggregation of projects into elements sometimes appears arbitrary and regrouping is done periodically. Improvement in the way projects are designated could conceivably result from more thorough research into this subject.

The Formal Planning System from the OCRD Point of View

Substantive Planning. The guidance to OCRD on substantive matters from other parts of DA, and from DOD, is generally contained in documents of which Army R&D matters are only a part: as the guidance for planning moves from the higher echelons on down, guidance documents specific to the Army R&D program begin at the OCRD level. Note that as is common practice for Army staff agencies in general, the initial input of the Army's part of the written material is often done at the lower level—OCRD in this case. It is then reviewed and issued by ODDR&E or JCS. As indicated in Fig. 3-3, the OCRD originated documents providing formal guidance for the fiscal and content parts of Army R&D programs include at the DOD level:

- DCPs —Development Concept Papers (these treat individual programs in the overall)
- ACPs —Area Coordination Papers
- TCPs —Technology Coordination Papers
- JRDOD—The Joint Research & Development Objectives Document
- JSOP —The Joint Strategic Objectives Plan, and
- JLRSS—The Joint Long Range Strategic Study

At the DA level the guidance is contained in:

- ASOP —Army Strategic Objectives Plan, and
- CDOG —Combat Development Objectives Guide

The ASOP is the basis for the division of the R&D program into 15 objective areas (examples: STANO, Tank Antitank, or Air Mobility) and in turn these are used as one basis for overall priorities. The CDOG, too has priority guidance. It is a catalog of requirements and their potential solution by means of development activities. (Much of the specific requirement inputs in the CDOG document are originated in CDC.)

At OCRD the ARDP, the Army Research and Development Plan, is originated. As components of this currently evolving plan there are various separate documents:

- The R&D Planning Guide,
- 15 separately bound ASCODs (Army Systems Coordination Documents), one for each ASOP Objective Area,
- Threat estimates, one for each ASCOD document,
- A Research and Technology Coordination Document,
- A Non-Materiel Objectives Coordination Document, and
- Proposed documents on Priorities and on a Plan for all Army Laboratories

As a separate matter, OCRD is also responsible for the preparation of the LRTF, Long-Range Technical Forecast.

The plans so prepared at OCRD and Army level are used as guidance by the developing agency, but the flow of information is both upward and downward; inputs of information to the ARDP come from CDC and AMC.

Fiscal Planning from OCRD Point of View. Guidance for the formulation of R&D fiscal plans comes from DOD and DA sources as suggested in Fig. 3-3. The information flows in the documents have a strong cyclic variation caused by the different needs for preparing next year's budget and allocating funds from the currently available monies. The cycle is suggested in Fig. 3-1, already discussed. Separation of the Army R&D budget guidance on the one hand, and the proposed budget on the other are reasonably clear in Fig. 3-3, but the figure does not show the allocation of the funds at DA level, a process that involves "strawman" solutions proposed by OCRD personnel.

OVERALL PLANNING - THE INFORMAL SYSTEM

Description of Process

At any particular level of R&D planning and programming, the informal flow of information guides the work strongly and affects decisions that are made official by the document chain already described. There is, of course, input of information on specific single programs as part of the decisions made on groups of programs. There are also interactions between the content and the fiscal planning, as for example, when a successful experiment or test in a current year's program is reflected in the next year's allocations. Much of such interaction comes about on an informal basis: the documentation takes time and tends to lag the informal system except on controversial or fiscally sensitive decision area. The formal system, of course, makes some decisions "jell," but the direction the decisions take tend to be based not on the previous documents in the chain, but rather on informally acquired information.

At the OCRD level the project monitors, among other duties, act as important links in the informal net. They interact with personnel at various levels concerned with their specific areas, from laboratory section heads to DASSOS or to personnel in ODDR&E. The subjects discussed range from details of the latest lab tests to five-year fiscal plans for the area of concern. One of the important informal activities of OCRD project monitors is preparation of impact statements for budget or fund allocation actions contemplated for strawman proposals by the OCRD Program and Budget Division.

Discussion of Process

The informal net is one means by which the highly individualistic nature of research programs is accommodated into the planning and control system. Its proper functioning depends on the initiative of individuals in the net, and their perceptions of the importance of component segments of the work, or of particular happenings in the programs. Thus the net tends to reflect the capabilities or even prejudices of the individuals who work within it. In particular, action officers at OCRD tend to become proponents for their assigned program areas. The possibilities of overlooked facets of projects exist, but also the opportunities of serendipities.

Study of the net as a research topic is difficult because of the wide ranges of differences in program content, and in the individuals who are part of the net, and also because of the transient nature of the information transfer. Previous research by others on the informal transfer of technical information at a laboratory level has indicated that person-to-person transfer is highly important to proper functioning of the system.

The preliminary investigations of the R&D planning process reported on here did not uncover any specific problem areas in the informal system. It seems clear without detailed analysis, however, that there are wide differences in the efficacy of the various parts of the nets, corresponding to the differences among the individuals who form the information links.

Informal nets and delegation of authority. Another facet of the informal information exchange that needs to be kept in mind is the need of the lower levels for guidance and of the higher levels for specified information on the projects, and of some flexibility of authority in between. The research accomplished so far on the R&D planning process does not confirm nor deny the speculation that informal exchanges are more effective in this upward and downward flow than formal means would be.

To be more specific, the echelons doing the actual R&D work are in direct contact with the physical problems that stand between the present state of the project and successful solutions to it; these echelons need to have a say in directing their own work because only they understand all the immediate problems. At the same time, the lower echelons of research have been observed to have quite different goals and incentives than the higher echelons and to have little knowledge nor interest in such matters as the methods by which R&D funds are allocated.* For instance, they may well not appreciate the comparative role of the system they are working on versus other competing systems.

*Arthur D. Little Study, "Management Factors Affecting Research and Exploratory Development," AD 618321.

The speculation is that the informal system tends to fulfill these informational needs. It seems hard to imagine that a formal system that required a step-by-step, echelon-by-echelon approval of a researcher's request to do an experiment would work rapidly enough to keep from falling of its own weight: to the degree that informal arrangements can be substituted, and that authority for diverting some part of the total expenditure is available, the needed flexibility may occur. Evaluation of the needs for such flexibility, on the one hand, and of the dilution of control that accompanies it, on the other hand, is an unexplored area in the current R&D system.

Chapter 4

SOME SHORTFALLS AND OPPORTUNITIES

INTRODUCTION

As has been previously discussed, the prime purpose of planning is to control. Since control is the function of making sure that events conform to plans, no manager can control who has not planned.

The current climate of increased competition for scarce national resources and the criticism of cost overruns, performance degradations and schedule slippages associated with certain major weapon systems has focused attention upon the life cycle management process of which R&D planning is the initial phase.

The interest in improving Army R&D planning is manifest by the creation of a new hierarchical family of RDTE plans from commodity command level up through OCRD level. The elements of this family are evolving independently of one another so that in terms of structure, formats, inputs and outputs, the initial efforts often exhibit incompatibility, inconsistency, incompleteness, and some redundancy when compared. In addition, problems have arisen concerning the usage of the individual planning documents, particularly in terms of their ability to influence and subsequently reflect executive level decisions.

The current concept of an Army integrated planning system is described below. The elements and interrelationships of the system are described and strengths and weaknesses are identified. A number of key issues that must be addressed within the framework of this concept are highlighted and a mechanism for assisting the integration of the individual elements is outlined.

CURRENT PLANNING SYSTEM CONCEPT

Depicted in Figure 4-1 are the basic elements and functional relationships of the current concept for an Army Integrated Planning System. A hierarchical structure is shown in which lateral integration of the individual elements will be accomplished respectively by OCRD, developing agencies, and the individual commodity commands and laboratories. The responsibility for the vertical integration shown in Fig. 4-1 has yet to be established.

The initial versions of most of the elements within the system have been completed. Several have yet to be completed, but further iterations are expected of each element in order to achieve lateral integration and subsequently, vertical integration of the hierarchical groups.

Army R&D Planning System (ARDPS). The purpose of the ARDPS is to provide a basis for planning R&D activities in support of objectives and needs, and for the allocation of RDTE resources. The ARDPS consists of a series of key Army R&D planning documents:

The R&D Planning Guide is the central document. It provides essential statements of R&D philosophy, guidance and objectives. This document has been published in draft form.

Threat Estimates relating to each of the materiel objectives of the ASOP provide succinct information on the tactical and technical threat. This is a companion series to the Army Systems Coordinating Documents. This series has been published.

Army Systems Coordinating Documents (ASCOD) cover the R&D efforts directly associated with the materiel objectives of the ASOP. The purpose of the ASCOD is to show the relationship among future Army systems needs and the Army RDTE effort. ASCODs identify the current efforts to satisfy approved needs, highlighting pacing activities and problem areas. The initial versions of these documents have been published.

The Non-Materiel Coordinating Document (NMCCOD) identifies the R&D effort associated with the non-materiel objectives

INTEGRATED R&D PLANNING SYSTEM

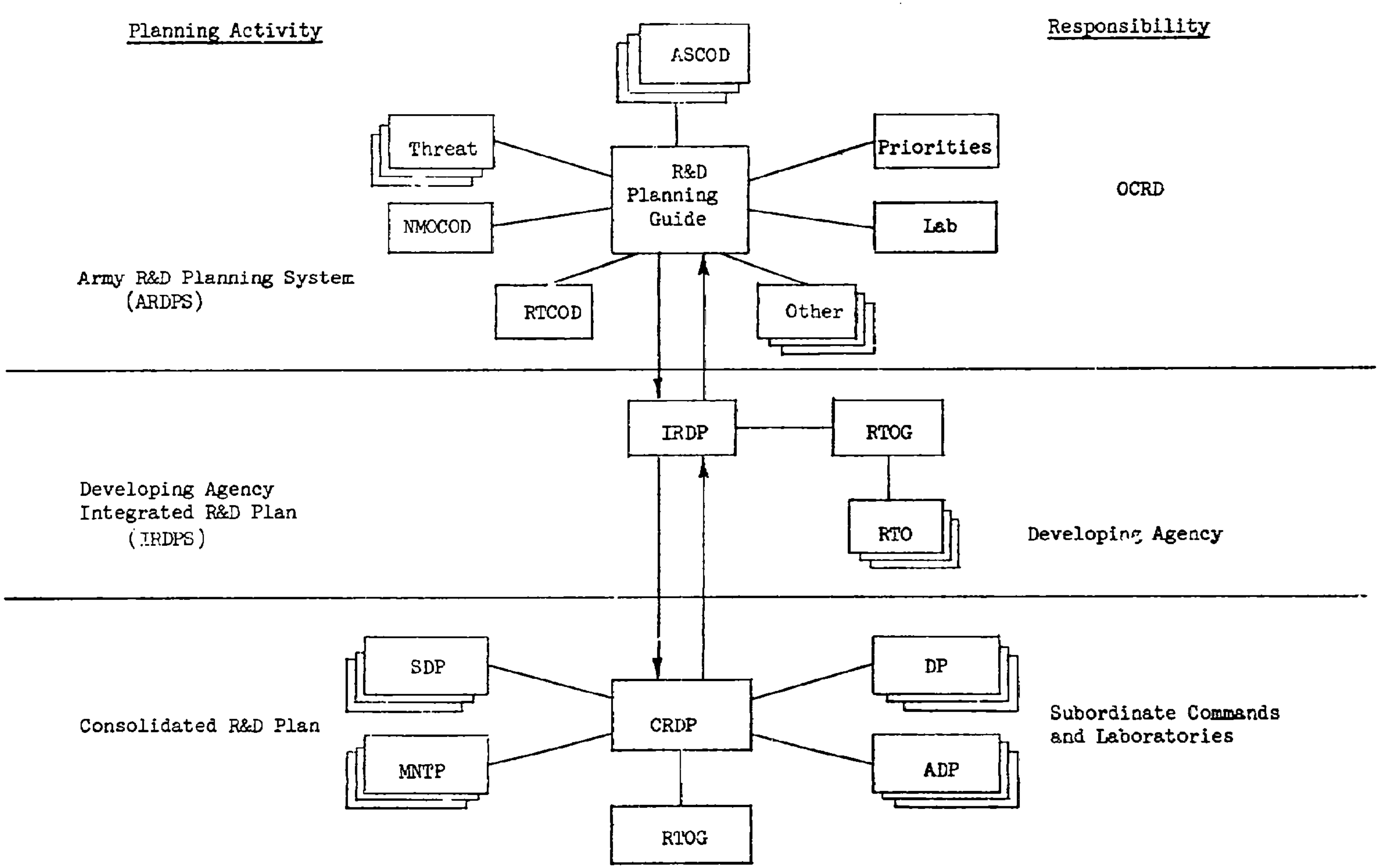


Fig. 4-1—Integrated Planning System

of the ASOP in much the same fashion as the ASCOD series address materiel objectives. The purpose of the NMOCOD is to show the relationship between the Army's needs in non-materiel areas and the research programs that serve to meet the needs, and as an informational input to the process of allocating R&D funds. The NMOCOD has been published.

The Research and Technology Coordinating Document (RTCOD) presents the technology needs and problems identified in the ASCOD series together with similar items from the NMOCOD and those items of opportunity or high payoff not yet related to specific materiel systems. The purpose of the RTCOD is to concisely define the 6.1 and 6.2 effort in a structured manner which displays the relationships (1) within the 6.1 and 6.2 programs, (2) between 6.1 and 6.2 efforts and derived ASOP sub-objectives, and (3) between related planning documents now under development, e.g., ODDR&E Technology Coordinating Papers and Developing Agency planning documents. The RTCOD will eventually replace the Army Research Plan. The current RTCOD has been published as an interim document which will be modified and expanded prior to its up-date in February 1972.

The Laboratory Document will present information on R&D community personnel and facilities needed for coherent program planning. This document has not been published.

The R&D Priorities Guide is expected to provide priority guidance on materiel and non-materiel efforts within a framework of RDTE projects. This document has not been published.

Other documents to aid the staff planning process in such areas as cross-referencing and other service and allied developments will be added as the need becomes apparent. No other documents have been published.

Developing Agency Integrated R&D Planning System (IRDPS). The purpose of the IRDPS is to provide a means of integrating all Developing Agency R&D planning activities and to produce a Developing Agency planning document responsive to higher level planning guidance, i.e., ARDPS. The IRDPS has been partially designed and is currently planned to be developed for operation within the Developing Agency R&D community.

Developing Agency Integrated R&D Plan (IRDP). The purpose of the IRDP is to provide a document useful to Developing Agency management in providing the following:

(1) Basis for subsequent programming and budgeting decisions, and other management actions including the allocation of resources.

(2) Input to the ARDPS.

(3) Guidance to the major subordinate commands and commodity laboratories for preparing their CRDP.

The IRDP will include the objectives for the entire RDT&E program, planning premises, alternatives, identification of the projects and tasks with estimates of technical risks, time, and resources needed to achieve the objectives. The IRDP will emphasize planning to achieve long-range objectives expressed as Research and Technology Objectives. The IRDP must be responsive to higher level R&D planning guidance and requirements, and be compatible with the Developing Agency resource management system.

Research and Technology Objectives (RTO) and Research and Technology Objectives Guide (RTOG). The purpose of RTO is to provide approved objectives for research (6.1) and exploratory development (6.2) efforts. RTO will complement Materiel Needs (MN) in that MN are intended to provide objectives primarily for advanced development (6.3), engineering development (6.4), and operational systems development (6.7).

Consolidated R&D Plan (CRDP). The purpose of the CRDP is to provide a plan of R&D activities for short-, mid-, and long-range periods to achieve the entirety of Army objectives for which the command or laboratory is responsible. The CRDP provides the basis for timely planning decisions by management, which are implemented by subsequent programming, budgeting, and other management actions. CRDP are prepared by the major subordinate commands and corporate laboratories in coordination with appropriate CDC elements. The CRDP is discussed in detail under LCMM Block 13a of the Joint CDC/AMCA Materiel Needs Procedure Handbook dated 15 September 1971. Inputs to the CRDP are System Development Plans (SDP), Development Plans (DP), Advanced Development Plans (ADP), the Research and Technology Objectives Guide (RTOG) and Material Need Technical Plans (MNTP). Only DPs, SDPs and ADPs have been published.

The subsequent discussion pertains primarily to the upper part of Fig. 4-1, ARDPS as it has evolved furthest and is of dominant concern to OCRD.

The key issue facing ARDPS is the manner in which the individual elements shown in Fig. 4-1 are to be integrated into a planning system. As indicated in Fig. 4-1 the R&D Planning Guide will provide the mechanism for integrating the respective elements. The format for this document as suggested by Plans Division of OCRD is:

1. Overall Policy Guidance. Statements of RDTE philosophy, significant policies, and guidance on activities that cut across the entire RDTE process. An example would be a statement of specific requirements for the timely and complete reporting of R&D information.

2. Program Guidance. This section might include guidance on:
   - (a) Use of the ASCODs, RTCOD, NMCCOD and Lab Plan (LABCOD?)
   - (b) Threat and intelligence production requirements
   - (c) Requirements documentation system and status
   - (d) Priorities

3. Financial Guidance. (To be furnished by P&B)

It is hoped that one of the current problems concerning the use of ARDPS for influencing executive decisions can be resolved if the R&D Planning Guide successfully integrates the information contained in the other constituent elements of ARDPS. As a minimum, integration implies a crosswalking capability among the documents. Facilitating such crosswalks, especially when frequent updates are required to prevent "staleness" would be the development of a computer-based information system for retrieving, processing and cross referencing the essential elements of information contained in these documents.

In addition to providing a mechanism for integrating the constituent elements of ARDPS, the R&D Planning Guide should provide the basis for the issuance of substantive guidance to the field. Before coherent guidance can be issued certain basic questions must be answered. These include:

1. What are the broad planning/decision issues that the system (ARDPS) is designed to address?

2. What specific planning/decision issues is the system meant to address?

3. What issues are not meant to be addressed by the system?

4. What raw and processed information is needed and with what timeliness in order to address these questions?

5. How should this information be presented to be useful?

Review of the contents of the individual elements of ARDPS leads to the conclusion that the information currently contained within each is pertinent, yet when viewed independently, is insufficient to answer such basic planning/decision questions. Some examples can help illustrate this point.

The ASCOD/NMOCOD/RTCOD family of documents provide the basic data source for ARDPS. The 14 ASCODs (15 in the update), one for each of the ASOP objective areas, provide narrative descriptions and performance, cost and schedule data for the approved objectives/requirements. In addition, a matrix showing technology/task vs objectives/requirements is provided, as shown in Figure 4-2. Indications of the adequacy of funding is portrayed by the symbols filling in the matrix. The matrix exhibits the interesting properties that individual budget entities (e.g., tasks) are often related with various degrees of relevance to multiple objectives/requirements, and many separate efforts are required for the achievement of each objective/requirement.

While the matrix presentation is intrinsically interesting, one wonders what planning/decision issues such a presentation is designed to resolve? The inclusion in the matrix of data pertaining to funding adequacy leads one to infer that resource allocation issues are meant to be addressed. If this fact is an intended purpose, difficulties arise, since the budget entities are not unambiguously described as either tasks, subtasks or work units. The funds allocated cannot be identified if the budget entity isn't specified.

OBJECTIVES/REQUIREMENTS

AIRCRAFT SYSTEMS

TECHNOLOGY/TASKS	AH-56	HLH	UTTAS	MAVS	LTTAS
ADVANCED ROTARY WING AIRCRAFT (63204D157)					
ABC ROTOR	■		■		
TELESCOPING ROTOR	■		□	□	□
AERO FLUID MECHANICS (AA41)					
BOUNDARY LAYER STUDIES	■	■	■	■	■
AEROMECHANICS (AA42)					
EVAL ROTOR HOVER PERF THEORIES	■	■	■	■	■
FLIGHT LOADS (AA43)					
SUBHARMONIC INSTABILITIES	◒	■	■	■	■

The symbology shown below is used to identify those developments which are necessary (pacing) to field a system or component and those development areas which will provide an additional capability, (supporting) to the total requirement.

	Funded	Minimum Sustaining Level	Unfunded	Unfunded But Benefiting
PACING	●	◒	○	⊖
SUPPORTING	■	⬓	□	⊟

The current DA project number (last 4 digits) is also shown to assist the user in obtaining fund information concerning the technology areas being pursued. A sustaining level of funding implies that the project cannot be further decremented without fear of becoming unfunded. Funded indicates a level higher than sustaining level, but does not imply adequacy. Unfunded but benefiting implies that the project receives benefits from a development being pursued in another area.

Fig. 4-2—ASCOD Matrix

Also, the matrix provides some indication of the relative adequacy of current funding to each budget entity. Again, if resource allocation issues are to be addressed, the funding level that would be adequate for each budget entity should be specified. For the concept of adequacy to useful, it must be defined in terms of specific criteria such as "funds required to meet an IOC date of ..." In addition, some measure of the impact of underfunding is required. The pacing and supporting relationships presented in the ASCOD matrix provide a qualitative measure of impact. Refinement of this concept is necessary if unambiguous impacts vs funding information is to be provided.

In summation, the ASCOD/RTCOD/NMOCOD family provide an important first step toward providing information that would be useful for resource allocation purposes. However, lack of precise definition of the budget entities listed, their requirements for funds and the impacts of underfunding, limits their current utility.

Additionally, the RTCOD is meant to complement the ASCODs by relating, in a matrix similar to the ASCODs, the relationship of the 6.1 and 6.2 efforts to the linking technologies supporting the objectives/requirements listed in the ASCODs. In order to be compatible with the ASCOD format, the linking technologies should be identical to those identified in the individual ASCODs. In the first iteration of the RTCOD, the linking technologies were defined to be ASOP category linking objectives. These differed from those linking technologies defined in the ASCODs. To enable an ASCOD/RTCOD crosswalk, this ambiguity must be resolved. Further, indicators of relative funding adequacy were not presented in the initial RTCOD. Again, to be compatible with the ASCODs, such data should be provided. Of course, concepts of funding adequacy for 6.1 and 6.2 efforts present difficulties since these have traditionally been treated as level of effort areas. However, the new MN concept suggests that the justification of 6.1 and 6.2 efforts should be based upon specific research and technology objectives (RTO) which are to be specified and approved. Adequacy could then be based upon estimates of funds required for achievement of an RTO. The RTO's, which have yet to be formally adopted, should be quantified to the extent possible and specified in a taxonomy compatible with that of the ASCODs and RTCODs if they are to be useful.

The initial NMOCOD contains mainly a narrative description of the on-going efforts. If the NMOCOD is to be made compatible with the ASCOD/RTCOD family, it too must contain a matrix structure relating budget entities to objectives/requirements. In addition, levels of funding required must be incorporated.

Once the structural anomalies and incompatibilities of the ASCOD/RTCOD/NMOCOD family have been corrected, integration of the above information with that contained in the companion (see Fig. 4-1) threat documents and priority guide will be required if resource allocation issues are to be addressed on the basis of full use of all relevant information.

Threat documents have been prepared for each ASCOD. In order to be compatible with the ASCODs, a crosswalk should be provided linking the objectives/requirements listed in the ASCODs to the threat data. The threat documents do not currently provide this crosswalk.

The priority guide is currently in draft form. Its purpose is the development of priorities for individual budget entities that can be translated into resource allocations which are aggregated upward to program element level. In the current version of the priority guide, the budget entities for which priorities are developed are not identical to those listed in the ASCODs. Therefore a crosswalk between the information in the priority guide and the ASCODs isn't available. Moreover, the priority guide does not currently attempt to develop priorities for each of the objectives/requirements listed in the ASCODs. A crosswalk between the objectives/requirements listed in the ASCODs and their respective priorities would also be useful for resource allocation purposes.

A structurally integrated system composed of the ASCOD/RTCOD/NMOCOD relevance matrix, coupled with financial, threat and priority data would provide a framework for addressing resource allocation and other planning issues in a comprehensive and cohesive manner. Questions to which rational insights could then be provided include:

(1) Which combination of objectives/requirements could or should be funded within budget limitations?

(2) Which projects and tasks should be funded and to what levels?

(3) What should be the technological content of the RDTE budget?

(4) How should the tech base be sized and balanced?

(5) What systems and technologies are being developed to counter specific threats?

(6) What threats exist to which we are not planning any response?

Outlined below is an R&D planning and information system for addressing these and related questions. It uses the data base provided by a structurally integrated ASCOD/RTCOD/NMOCOD family coupled with threat data and priority indicators and other essential elements of information. Description of the development and the use of this system could provide the nucleus of the R&D planning guide.

AN IMPROVED R&D PLANNING AND INFORMATION SYSTEM

The proposed R&D planning and information system is based upon the ASCOD/RTCOD/NMOCOD matrix format relating the relevance of Budget Entities (BE) to Material Needs (MN) and Research and Technology Objectives (RTO). The system would provide the framework for testing planning assumptions and developing coherent guidance to the field concerning the content of the R&D program. It could then be used to provide one of the means of controlling the RDTE problem by highlighting any discrepancies between the RDTE program submitted by the Developing Agencies and the guidance provided them.

System Features

Figure 4-3 illustrates the basic information structure of the system. Depicted is the interaction of the MN/RTO with the threat (T) and with the budget entities (BE) which support the (MN/RTO). Each cube contains concisely structured quantitative data and supporting narrative information providing justification and rationale for each MN/RTO. Additionally, net assessment information relating each MN/RTO to the threat and data pertaining to the resource requirements of individual (BE) to each MN/RTO is shown.

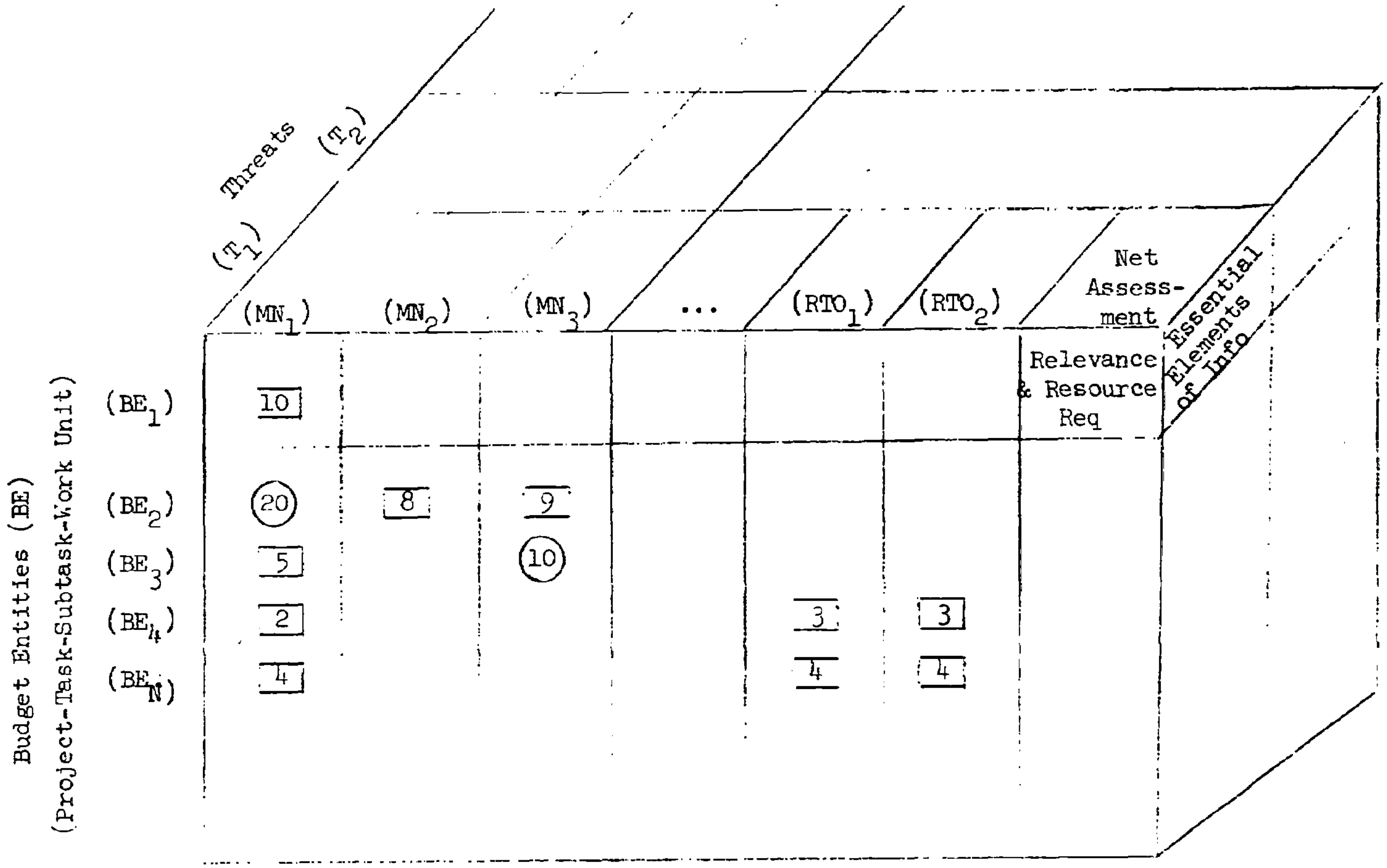


Fig. 4-3—Data Base Structure of R&D Planning and Information System (ASCOD Family Cube)

The set of MN's are those to be contained in CDOG as revised by the MN process. These would typically cover most (if not all) 6.7, 6.4, and 6.3 work. The set of RTO's are yet to be precisely specified but are implied by the MN process. The RTO's would justify 6.1 and 6.2 work. Essential elements of information pertinent to each MN/RTO would be provided. Table 1 illustrates a typical list of the information categories and data elements. Each MN would be specified in quantifiable terms such as specific performance bands and IOC or timeframe required. The degree to which the RTO's should or could be quantified is yet to be determined but the specifications of both MN and RTO should be so stated as to provide the basis for the laboratories' determination of current and projected resource requirements for individual budget entities (BE).

The budget entities (BEs) are collections of the entities currently used in budget preparation (e.g., project, task, subtask) aggregated according to the appropriate one of the following rules:

1. Aggregate the largest package of work that is uniquely associated with a single MN/RTO.
2. Aggregate the largest package of work associated with a group of MN/RTOs but so aggregated that the entire work package is equally applicable to every MN/RTO in the group.

For instance, a specific (BE) could be a project if all of the efforts (tasks) contained were totally associated with the same single or group of (MN/RTO). However, if one task within the project was related to one MN/RTO and another task within that project was related to another MN/RTO, the tasks would be shown separately instead of the project as a budget entity. In addition, if part of one task was associated with one MN/RTO while the rest was associated with another MN/RTO, then subtasks would be shown. Fig. 4-4 illustrates an application of the above rules. Note that a lack of precise defining rules for the budget entities presented in the ASCODs resulted in a lack of standardization and ambiguity.

While the above rule may appear at first to be rather arbitrary, its rationale will become apparent if one desires to calculate the resource implications associated with the achievement of more than one MN/RTO which are interdependent.

Table 4-1

ESSENTIAL ELEMENTS OF INFORMATION
(ASCOD Family Cube)

Characteristics of MN/RTO

- CDOG or Req Ref
- Performance Characteristics
- Life Cycle Cost and Schedule Info
- Other Milestone Data
- Responsible Facilities
- Related Subsystems
- MN/RTO Systems Replaced
- Barriers
- Success Probabilities
- Impacts of Prescribed Funding Adjustments
- Priorities
- Environmental, Tactical, and Doctrinal Info

Characteristics of (BE)

- Level of Aggregation, e.g., Project, Task
- Subordinate Efforts Included, e.g., Subtask, Work Unit
- ARDIS Descriptor for Sort Purposes, e.g., COSATI Code
- Relationship to MN/RTO {Pacing / Supporting} and CDOG Paragraphs
- Funding Requirements (budget year, five year and cost to completion)
- Other Resource Requirements (manpower, facilities)
- Milestones
- Success Probabilities
- Impacts of Funding Adjustments
- Priorities

Net Threat Assessment

- Physical Characteristics of Threat
- Operational Characteristics of Threat
- Doctrinal Implications
- Trends and Forecasts
- Counter Provided by MN/RTO
- Impact of Performance Degradation, Schedule Slippage or Cancellation of MN/RTO

BUDGET ENTITY	TITLE	AH-56	HLH	UTASS	MAVS	LTTAS
		AIRCRAFT SYSTEM				
TASK	ABC ROTOR	■		■		

SELECT AS BUDGET ENTITY, THE LARGEST PACKAGE OF WORK, I.E., WORK UNIT, SUBTASK, TASK, PROJECT WHOSE OBJECTIVE IS COMMON TO ONE OR MORE SYSTEMS. AS INDICATED ABOVE, THE TASK ABC ROTOR HAS APPLICABILITY TO BOTH AH-56 AND UTASS.

IF, HOWEVER, THE TASK ABC ROTOR IS COMPOSED OF TWO SUBTASKS EACH UNIQUELY RELATED RESPECTIVELY TO AH-56 AND UTASS THE MATRIX WOULD BE:

BUDGET ENTITY	TITLE	AH-56	HLH	UTASS	MAVS	LTTAS
SUBTASK	ABC ROTOR (A)	■				
SUBTASK	ABC ROTOR (B)			■		

Fig. 4-4—Rule for the Resolution of the Budget Entity Listed in ASCOD Matrix

Illustrated in Fig. 4-3 (within the ○ and □ shown, respectively indicating pacing and supporting relationships) are estimates of the resources required for each (BE) to achieve the performance/schedule objectives associated with each MN/RTO. These resource estimates could be budget year cost estimates, 5-year estimates, costs to completion, or even total costs and manpower and facilities estimates. Exactly which of these will be most useful to planners and decision makers can be resolved later. The level of resources required for an individual (BE) affecting several (MN/RTO) needs to be based upon individual considerations of the relationship of a (BE) to each MN/RTO affected. For example, if a specific (BE) is related to several MN/RTOs which are required to be available during different timeframes, respectively different funding profiles for the (BE) could be appropriate for each (MN/RTO).

Fig. 4-5 illustrates this point with an example of a specific task, ABC Rotors, that has applicability to both AH-56 and UTASS. Also it is assumed that the MNs for AH-56 and UTASS specify respective IOC dates of 1976 and 1980. In order to achieve the objectives of the ABC Rotor in time to have an impact upon AH-56, the funding profile shown in Fig. 4-5 is developed. The funding profile is developed using the rule that the task objectives are completed with high probability no earlier than that required for implementation on each related system. Therefore, using this rule, the later IOC date of UTASS would allow a stretchout of the funding profile for ABC Rotor, with the consequence of a short timeframe savings, yet with an eventual larger completion cost.

The purpose of such a rule for defining separate funding profiles for each task is to provide planners options in situations where the funds required to achieve all approved MN/RTO by their respective timeframes is not available. In such situations, one may not be in a position to select the obviously preferred funding profile for ABC Rotors that allows AH-56 to be available by 1976. Note that this profile will also allow the accomplishment of the task objectives in time for UTASS to meet its 1980 date. However, budget ceilings might force the selection of the profile of Fig. 4-5 keyed to the 1980 UTASS availability date, with the consequence of compromising the 1976 availability date for AH-56.

	AIRCRAFT SYSTEM/IOC												
	AH-56/1976				HLH/1985	UTASS/1980							
	FY					FY							
TASK	73	74	75	76		73	74	75	76	77	78	79	80
ABC ROTOR	2	2	2	2*		1	1	1	1	1	2	2	2*
BUDGET YR FUNDS	2					1							
FIVE YR TOTALS	8					5							
COST TO COMPLETION**	8					11							

Fig. 4-5—Rule for Developing Funding Requirements vs Systems for Each Project, Task, Subtask, Work Unit Listed in ASCOD Matrix

The funding profiles are developed using the rule that the task objectives are completed with high probability no earlier than that required for implementation on each related system.

*Funds are in 1972 constant dollars.

**Discounting could be used to provide other comparisons.

The reporting of such alternate funding profiles as shown in Fig. 4-5 will provide decision makers the opportunity to evaluate and assess the impacts of alternate resource allocations. In fact, one may wish to specify several IOC dates for each system for which a task was related, and if it proved feasible, require funding profiles keyed to each. With a number of such data points used as bench marks, interpolations and extrapolations could be used by planners to estimate objectively the potential impact upon milestones and completion costs of any arbitrary allocation.

However, in order not to obscure the basic principles involved, let us stick with a simple situation in which for each task, one funding profile is developed for each related (MN/RTO).

We shall show how such information would be used for planning purposes. Fig. 4-6 portrays a two dimensional vertical slice of Fig. 4-3. The numbers within the ◯ and ☐ represent, as example, the budget year funds. These are developed from funding profiles keyed to each related system as illustrated in Fig. 4-5.

Timeframe or IOC	1975 (MN_1)	1980 (MN_2)	1982 (MN_3)	....	1985-1990 (RTO_1)	1980-1985 (RTO_2)	....
(BE_1)	$\boxed{10}$						
(BE_2)	20	$\boxed{8}$	$\boxed{7}$				
(BE_3)	$\boxed{5}$		10				
(BE_4)	$\boxed{2}$				$\boxed{3}$	$\boxed{4}$	
(BE_5)	$\boxed{4}$				$\boxed{3}$	$\boxed{4}$	
Indiv Tot	41	8	17		6	8	
Cum Tot	41	41	46		47	48	

Fig. 4-6—Budget Year Funding Requirements for (BE) to Contribute to (MN/RTO)

When available budget year funds are insufficient to allow all (BE) to be funded at levels required to achieve each MN/RTO by their required timeframe (note in the case of RTO some criteria other than timeframe may be used to justify funding requests) decisions may be made to either slip or cancel one or more (MN/RTO). The Individual Total row of Fig. 4-6 shows the budget year funding requirements of each MN/RTO assuming no other (MN/RTO) were funded. The Cumulative Total row indicates the incremental cost of adding each subsequent MN/RTO in order. Note for instance, that the cost of (MN_1) is 41 while the cost of (MN_1) + (MN_2) is also 41. As seen in Fig. 4-6, this results from the fact that the resource requirement in the budget year of 20 for (BE_1) in order to achieve (MN_1) is greater than the 8 that would be sufficient for (BE_1) if only (MN_2) were to be developed.

The Figure 4-6 matrix can therefore be used to price out various combinations of MN/RTO in order to discover alternatives that are feasible within budget year constraints. When a (BE) contributes to more than one MN/RTO only the largest of the several values listed in the matrix for that (BE) is added to the total. In addition, those MN/RTO that are partially achieved as bonuses are seen. For instance, the development of (MN_1) by 1975 requires, as seen in Fig. 4-6, a total budget year funding requirement of 41. As is seen, (MN_2) is totally achieved as a bonus, while (MN_3) (RTO_1) and (RTO_2) are partially achieved.

The incremental funding requirements associated with the addition of any specific MN/RTO to a previously selected group could also be extracted.

Another use of the system could be to assess the savings accrued by cancelling an individual or group of MN/RTO. Note from Figure 4-6 that the cancellations of (RTO_2) only saves the amount 2 since the (BE_4) and (BE_5) must still be funded respectively at amount of 2 and 4 in order to achieve (MN_1).

For each combination of MN/RTO that was discovered to be feasible within constraints, the 5 year funding totals and costs to completion could also be provided for comparison with other alternative feasible solutions.

The uses of the system described above pertain to answering "what if" questions concerning the total resources required to achieve combinations of (MN/RTO). At this point the question naturally arises concerning which of the combinations of MN/RTO that are discovered to be feasible within fiscal constraints are most desirable. Before addressing this question, let us note that an auxiliary use of the system would be to answer "what if" questions concerning the funding of the individual (BE) that contribute to the achievement of multiple (MN/RTO). For instance, referring to Fig. 4-6, one might ask what is the impact upon the schedules of the related MN/RTO of a budget year funding of 7 for (BE_2). It is seen that (BE_2) affects (MN_1), (MN_2), and (MN_3). Note that the funding level of 7 is sufficient only for (MN_3) in the sense that the task objectives are completed prior to the 1982 IOC date. The impact upon (MN_1) cannot be precisely ascertained from the data presented in the matrix. All that can be stated is that the task objectives for (BE_2) will not be completed in time for them to contribute to the 1975 timeframe for (MN_1) and the 1980 timeframe for MN_2. Additionally, however, one notes that (BE_2) is a pacing item for (MN_1) indicating that a funding level less than 20 will certainly cause the 1975 date to slip, whereas (BE_3) only supports MN_2 so that a funding level less than 8 will not necessarily cause a slippage in the 1980 IOC date. If additional funding profiles for each (BE) were provided which were keyed to several possible timeframes or IOC dates for each MN/RTO, more precise impacts associated with arbitrary funding assignments could be estimated using interpolation and extrapolation procedures.

If the system is to be used for allocating funds to each (BE), a set of priorities or priority indicators attached to each (BE) would be useful. Priorities developed in the R&D priority guide should therefore be relatable to each (BE). Once developed, these can be coupled directly to displays such as those of Figure 4-6. Current priorities are characterized by both a lack of adequate or generally acceptable criteria for their development and the lack of any precise operational rule for translating a priority indicator into a resource allocation. This latter problem is exhibited quite clearly in the published versions of the ASCOD family. Many (BE) which are indicated to be pacing items for one or more MN/RTO are unfunded or underfunded in contrast to other supporting items which are seemingly more adequately funded.

This apparent paradox indicates a lack of consistency in the development and use of priority guidance. Note also that several, possibly conflicting forms of priority guidance are currently promulgated for the Army RDTE effort. On one hand there are the 14 ASOP priorities by materiel area and the CDOG priorities I, II and III. These are in effect priorities on the set of MN/RTO. On the other hand, ACSFOR produces a priority list by (BE) at the project level. In order to assess whether priorities at MN/RTO level are compatible with priorities at (BE) level one can refer to the type of matrix shown in Fig. 4-6 showing the coupling between MN/RTO and the (BE). Consistency would suggest that (BE) of high priority should be related to MN/RTO of high priority. A crosswalk of the various types of guidance through the ASCOD matrix structure in order to verify internal consistency has not been accomplished. Therefore, it is not possible to assess the degree to which the various forms of priority guidance are or are not compatible. In addition, those factors used as priority determinants are rarely stated explicitly. Implicit are considerations of threat assessment, performance parameter improvement possibilities, life cycle system savings, improved maintainability, reliability or human factors considerations.

Even after an internally consistent (between MN/RTO and BE) set of priority guidance is established, the operational question of how it should be used in determining resource allocations must be settled. One possibility would be to insist that the highest priority MN/RTO should receive funding at a level sufficient to enable them to achieve their approved milestones with a specified high degree of confidence. Lower priority MN/RTO would be permitted decrements and therefore allowed to slip certain approved milestones in a prescribed manner when funds were insufficient to support all (MN). For instance 1 and 2 year IOC slippage allowances could categorize groups of MN with successively lower priorities. In the case of RTO's, allowance of milestone or timeframe slippage may not be as appropriate criteria as, for instance, allowances of reduced success probability.

The question of how such priorities could or should be established rationally and consistently, naturally involves, at a very minimum, information relating the MN/RTO to estimates of the threat. Returning to the three dimensional matrix of Figure 4-3, one can look at two dimensional horizontal slices, as illustrated in Figure 4-7, in order to assess the relationship of each MN/RTO to the set of postulated threats. Characteristics of the threat and the degree to which each related MN/RTO can counter the threat might be presented in the tableau in the form of impact statements. The impact statements could also provide some indication of the threat countering affects of an IOC slippage and/or performance degradation for the MN. Such information presented concisely and digestibly in a matrix format such as that shown in Fig. 4-7 would provide part of the basis for determination of rational and consistent priorities defined operationally in terms of resource allocation consequences for the (MN/RTO) and related (BE). In addition, other factors used as priority determinants such as life cycle system savings opportunities, possibilities for improved performance, maintainability, reliability, etc., could also be shown for each MN/RTO.

Return now to the question posed earlier concerning which of the combinations of MN/RTO that were discovered to be feasible to achieve within fiscal constraints, were in fact, most desirable. The information just discussed, coupled with additional essential elements of information such as that contained in Table 4-1 would provide a basis for assessing each fiscally feasible combination of MN/RTO.

	T_1	T_2	T_3	...
(MN_1)	Impact Statement . Threat Charac . Counters Provided by MN . Affects of IOC Slippage			
(MN_2)				
(MN_3)				
.				
(RTO_1)				
.				

Fig. 4-7—MN/RTO vs Threat Relationship

Operational Aspects & System Uses

Once the basic data base outlined in Fig. 4-3 and Table 4-1 is developed, and this would obviously be a staged process since some data elements would not be initially available, e.g., MN's would be prescribed before RTO's, the question arises concerning the manner in which planners would interface with the system in order to implement planning exercises. Because of the volume of data contained in the system and the types of manipulations envisaged, e.g., adding large arrays of numbers together, the system would have to be computer based. Additionally, a man-machine interactive capability utilizing remote input-output terminals or CRT displays would be desirable if quick reaction or "what if" exercises requiring exploration of many alternatives is required. The design could be similar to the MEASURE II on-line interactive system developed for OCRD for programming/budgeting formulation.

It is envisaged that once developed and implemented the system would be used primarily to assess the total RDTE resource implications of conscious decisions to achieve various combinations of the listed (MN/RTO). Since the resource implications of attempting to achieve all (MN/RTO) by their desired IOC dates or timeframes would surely be greater than the available RDTE resources, the model would be used to determine desirable combinations of MN/RTO that were attainable within fiscal constraints. The system could also show which additional MN/RTO are partially or totally achieved as bonuses and which are achievable with minimal additional cost. In order to decide which combinations of MN/RTO were most desirable, the system would provide planners storage, retrieval and display of essential elements of information, including priority indicators and net assessments of specific MN/RTO combinations versus the overall threat. Note also that each MN/RTO combination that was attainable within fiscal constraints would also be associated with a program content implied by the distribution of funds to each (BE). The various ARDIS sorts could be used to aggregate the required funds at (BE) level upward to project and program element level.

Use of the system in any of the manners suggested above would provide a basis for generating program content guidance to the field. The guidance could be in the form of the dissemination of a list of the most urgent MN/RTO, the priorities (in operational terms, e.g., allowed milestone or funding changes) of each MN/RTO, project or program element and suggestions of the resources required to achieve various combinations of MN/RTO aggregated by program category, ASCOD area, Developing Agency, Laboratory, Technology, etc. That is, guidance concerning the size and balance of the tech base could be generated. In addition, the rationale for such guidance could be explained in terms of agency resource limitations, net threat assessment, etc. The system would facilitate the ability to generate such guidance for differing total budget levels. Contingency plans therefore could be developed in advance of budget readjustments.

Used as a control mechanism the system would indicate discrepancies between the submitted (by the developing agencies) program and the guidance provided them.

One could also assess in quantitative terms the relationship of the actual program to the achievement of the complete set of MN/RTO. That is, one could discern which MN/RTO were ahead of or behind schedule by comparing the resources required for achievement of each MN/RTO with those actually being programmed.

Data Requirements

A large fraction of the essential elements of information of Table 4-1 and Figure 4-3 exists in ASCOD/NMOCOD/RTCOD, threat documents, CDOG, DD 1634 forms, etc. Some of this information needs to be restructured and reorganized. Additional data, not presently available, would be added as it became convenient. For instance, additional financial data required could be provided on supplementary forms attached to the DD 1634 forms. These forms currently report the funding requested and the relationship of project/task level efforts to CDOG items. The additional information pertains to separate funding profiles for tasks related to multiple MN/RTO.

In the special cases that data below task level were required to completely develop the Fig. 4-3 matrix, the specific subtasks would be broken out separately and redefined as tasks so that they could be reported within the 1634 framework.

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions are drawn from the above discussion and analysis.

1. The formal system for dissemination of RDTE planning information and substantive and coherent guidance pertinent for control of Army RDTE effort is replete with documentation that is redundant, inconsistent, incompatible and often incomplete or irrelevant for planning/decision purposes.

2. An informal system exists, consisting of directives, memos, phone calls, conferences and meetings, through which the planning and substantive guidance is effected.

3. At OCRD level, financial plans are used as the principal means of control of the RDTE program. Little attention is given to guiding the technology and system mix content of the total RDTE effort. OCRD must ask itself whether it should be, desires to be, and could obtain the information and expertise required to influence the program content of the RDTE effort.

4. The current efforts to develop a formally integrated RDTE planning system from laboratory and commodity command level up through OCRD and ODDRE level is an important first step toward correcting deficiencies in the existing system. However, unless a set of specific planning and decision issues are defined which are meant to be addressed by users of the system, current problems will subsist concerning the individual and collective use of the documents comprising the system. Additionally, subsequent iterations of these documents must be developed within a framework that consists of integrated formats and compatible structures in order that cross referencing capability is provided. This

cannot be accomplished, however, unless the responsibility for vertical integration of the system elements is defined and delegated.

5. A major weakness of the current planning system is a lack of consistent and operationally defined priorities. Many versions of priorities currently exist including ASOP priorities, CDOG priorities, and ACSFOR priorities. There is no mechanism guaranteeing the consistency of these different priorities. More important, however, is the fact that these priorities cannot be unambiguously translated into resource implications. The rationale or fundamental bases underlying the established priority values is also clouded. That is, implicit in the development of individual priorities are considerations of threat assessment, performance parameter improvement possibilities, life cycle system savings, improved maintainability, reliability or human factors considerations; yet these are rarely, explicitly surfaced as priority determinants.

6. A single priority system should be established for the total RDTE program. It should be defined in operational terms such as the specification of milestones for a specific MN which cannot be allowed to slip more than X years, or funds for a specific budget entity which cannot be reduced by more than Y%.

7. The computer based man-machine interactive RDTE integrated planning system discussed in the body of this report should be considered for development in order to provide OCRD a planning tool for evaluating alternative RDTE plans and as a mechanism for developing and testing program content guidance that might be promulgated to the field. The system will also provide the framework for affecting the integration of the various planning documents illustrated in Fig. 4-1 by requiring common structures and formats, and consistent, compatible and complete data. The system will also provide a convenient storage, retrieval, and processing device for manipulating and synthesizing large amounts of planning data for use in quick reaction and "what if" planning exercises.

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13. ABSTRACT

This report examines the purpose and nature of Army R&D planning as a part of the overall Army development process. It describes in broad terms the existing planning/decision making system for R&D including both its formal and informal structure. It then goes on to highlight some of the major deficiencies in that system and to recommend a number of feasible improvements. Probably the most significant contribution of this report lies in the concise basis it establishes for relating, i.e., cross-walking, among budget entities, R&D objectives, and technologies. These and other essential elements of information are contained in the documents being produced at the various hierarchical levels in the Army R&D community, but these elements are not now relatable in a concise and structured manner. This report also establishes a basis for priority determination and for answering certain planning and "what if" questions such as "how should the tech base be sized and balanced"? "what are the impacts of a budget reduction in the RDTE ceiling?" etc.

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